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DECAY OF POTASSIUM BY K-CAPTURE

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/A Digest./

Comparing the energetic aspects of various types of transitions, G. S. Si-
soo (1) arrived at the conclusion that if the middle member of a group of three
isobars of the type Z^A, $(Z + 1)^A$, and $(Z + 2)^A$ is radioactive and decays under
electron emission, it almost invariably may also be expected to decay under K-
capture. If this were not the case, the isobar Z^A could undergo transformation
by beta-decay into the middle isobar $(Z + 1)^A$ and would not exist as a stable
atom (2).

Among naturally occurring elements, the isobars A^{18}_{40}, K^{19}_{40}, and Ca^{20}_{40} comply
with Sisoo's conditions. K_{40} is radioactive and decays with the emission of a
beta particle. According to Sisoo's rule, decay of K^{19}_{40} by K-capture under for-
mation of A^{18}_{40} ought to be expected. This is confirmed by the diagram plotting
the logarithms of Clarke numbers /Clarke number indicates in weight percent
the relative occurrence of any element on earth/ expressing the occurrence of
noble gases. While the values for all other noble gases fit into a curve that
is parallel to the basic band containing the majority of elements which com-
pose the earth's crust, the point representing argon is approximately three
times higher than the rest of the curve. This indicates the presence of a con-
stant source of argon formation somewhere in the earth's crust. The decay of
K^{19}_{40} by K-capture of an orbital electron is not readily susceptible to direct
experimental proof, because the nucleus emits only a neutrino, and no charged
particles are formed in the process.

The following method works, however. The space which becomes free in the
K-shell is occupied by one of the orbital electrons, as a result of which char-
acteristic X-rays (principally K-quanta) are emitted. The new nucleus, which

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is formed by capturing an electron, has a charge which is lower by one unit, so that the shell alters in such a manner that it conforms to the new charge. Consequently, the X-rays must constitute characteristic radiation of the resulting rather than initial nucleus, i.e., characterize A_{40}^{19} rather than potassium. Existence of this type of soft X-rays has been established by Thompson and Rowland (3) in the case of potassium salts and has been investigated more fully by Bleuer and Gabriel (4). As has been suggested by Academician V. G. Khlopin and Professor E. K. Gerling (5), a direct determination of argon in potassium minerals and an investigation of its isotopic composition may also serve as a proof of the fact that K-capture by K_{40} results in argon. It is obvious that the transmutation is isobaric and that only A_{40} forms from K_{40}, while the ordinary light isotopes of argon (A_{38} and A_{36}) which compose atmospheric argon must be absent in potassium minerals.

Several tenths of a cubic centimeter of argon are necessary for a mass-spectrographic examination, and this quantity of argon can only be obtained from geologically old potassium minerals. For this reason we used sylvinite from the Solikamsk deposits, which are 200×10^6 years old. The argon content in this material being 0.5 cubic centimeter per kilogram, an adequate quantity of argon could be obtained from several kilograms of sylvinite by dissolving the latter in water and boiling the solution in vacuum.

The dried argon was investigated on a mass spectrometer of the Niehr type (6), the construction of which was given by M. G. Meshcheryakov. The ionic currents were measured by the charging method on a Lutz-Edelman electrometer. The mass-spectrometric determinations showed that the argon obtained from sylvinite is actually composed almost exclusively of the isotope having the mass 40, the isotope of mass 36, which on the average occurs to the extent of 0.30 percent in atmospheric argon, being practically absent. Consequently, the argon occurring in sylvinite cannot possibly be of atmospheric origin, and the decay of potassium by K-capture has been proven.

The quantity of argon found in sylvinite is approximately one-thirtieth of that calculated on the basis of the decay constant for K-capture, which in this case amounts to 1.9×10^{-9}/year according to Bleuer and Gabriel. The difference between the experimental value and the calculated value can only be explained by assuming that the sylvinite is of secondary origin and that it is therefore younger than the age of the surrounding deposits (200×10^6 years). According to Yu. V. Morachevskiy (7), sylvinite was formed from carnallite in a more recent geological period. On the other hand, the value for the constant of potassium decay by K-capture may not be quite exact.

A simple calculation shows that all the argon with mass 40 which is contained in the atmosphere must have formed in a period of less than 1×10^9 years, if Bleuer and Gabriel's constant is assumed to be correct. Provided that the value for the constant of decay by K-capture is exact and that a reliable method for the determination of argon is applied, the formation of argon from potassium and its presence in minerals can be used as a basis for determining the age of minerals.

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